CLASS TEST

S.No.: 01SK_ABCDEFG_27052024

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ANALOG ELECTRONICS

ELECTRICAL ENGINEERING

Date of Test : 27/05/2024

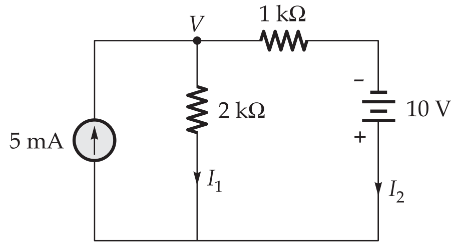
ANSWER KEY

1.	(a)	7.	(d)	13.	(b)	19.	(b)	25.	(c)
2.	(d)	8.	(c)	14.	(d)	20.	(d)	26.	(b)
3.	(b)	9.	(c)	15.	(c)	21.	(d)	27.	(d)
4.	(d)	10.	(b)	16.	(a)	22.	(d)	28.	(c)
5.	(a)	11.	(b)	17.	(a)	23.	(b)	29.	(a)
6.	(d)	12.	(b)	18.	(c)	24.	(a)	30.	(b)

DETAILED EXPLANATIONS

1. (a)

On applying short circuit test, D_1 and D_2 are replaced by short circuit



On applying Nodal analysis

$$\frac{V}{2} + \frac{V+10}{1} = 5$$

$$3V = -10$$

$$V = \frac{-10}{3}$$

$\therefore$ $$I_1 = \frac{V}{2} = \frac{-10}{6}\text{mA} < 0$$

So, D_1 off, $$I_1 = 0\text{ mA}$$

$$I_2 = 5\text{ mA}$$

2. (d)

Relationship between reverse saturation current and temperature can be given as

$$I \propto 2^{(T/10)}$$

$$\frac{I_2}{I_1} = \frac{2^{\left(\frac{T_2}{10}\right)}}{2^{\left(\frac{T_1}{10}\right)}} = 2^{\left(\frac{T_2-T_1}{10}\right)}$$

$$\frac{I_2}{I_1} = 2^{\left(\frac{T_2-T_1}{10}\right)}$$

$$T_2 - T_1 = 3°\text{ C}$$

$$I_2 = I_1 \times 2^{(3/10)} = 1.23\, I_1$$

$$I_2 = I_1 \times 123\%$$

So, % increased in I_2 = 23%

3. (b)

From the diode circuit,

$$I_D = \frac{V_i - V_{DO}}{r_d} = \frac{V_i}{r_d} - \frac{V_{DO}}{r_d}$$ → shows the PWL model of diode

So, option (b) shows the best characteristics of above diode circuit.

4. **(d)**

When $V_{in} > 2.7$, $D \rightarrow$ ON, $V_0 = V_i - 0.7$ V

$V_{in} < 2.7$ V, $D \rightarrow$ OFF, $V_0 = 2$ V

5. **(a)**

As we know,

$$\text{Gain} \times \text{Bandwidth} = \text{Constant} \quad ...(1)$$

Closed loop gain with –ve feedback is

$$A_{CL} = \frac{A_{OL}}{1 + A_{OL}\beta} \qquad (A_{OL} = \text{Open loop gain; } \beta = \text{Feedback factor})$$

Given : $A_{OL} = 100$, $(BW)_{OL} = 100$ kHZ

From eqn. (1), $A_{OL}(BW)_{OL} = A_{CL}(BW)_{CL}$

$$100 \times 10^5 = \frac{100}{1+100\beta} \times 10^6$$

$$1 + 100\beta = 10$$

$$\beta = 0.09$$

6. **(d)**

Let $V_o(t) = V_m \sin \omega_m t$

$$\text{S.R.} = \left|\frac{dV_o(t)}{dt}\right|_{max} = V_m\omega_m \cos \omega_m t = V_m\omega_m$$

$$5 = V_m(2\pi \times 10^7)$$

$$V_m = \frac{5}{20\pi} = \frac{1}{4\pi} \text{ Volts}$$

So, the largest sine wave output possible at a frequency of 10 MHz is $\frac{1}{4\pi}$ volts.

7. **(d)**

As we know,

$$V_o = A_{OL}(V^+ - V^-)$$

Since, $A_{OL} = \infty$ (for ideal Op-Amp)

So, $V^+ = V^- = V_{in}$

On applying KCL at inverting terminal

$$\frac{V^-}{3} + \frac{V^- - V_o}{2} = 0$$

$$2V^- + 3V^- - 3V_o = 0$$

$$5V_{in} = 3V_o$$

$$V_o = \frac{5}{3}V_{in} = A_V.V_{in}$$

$$\frac{V_o}{V_{in}} = A_V = \frac{5}{3}$$

8. (c)

It is non-inverting amplifier.

The gain, $K = 1 + \frac{R_F}{R_1}$

where, $R_F = R_Y$

$R_1 = R_X$

So, gain $K = 1 + \frac{R_Y}{R_X}$

9. (c)

$V_{GS} = 2 - 0.5$

$= 1.5 > V_{Th}$

MOSFET is ON

Assume, $V_{DS} \geq V_{GS} - V_t$ (current saturation)

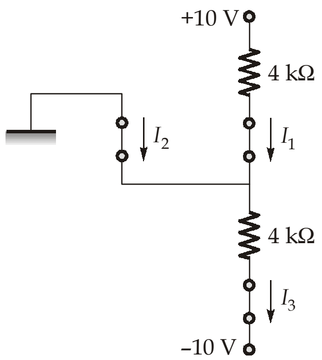
$2 - 0.5 \geq 2 - 0.5 - 0.4$

$1.5 \geq 1.1$

MOSFET is in current saturation.

10. (b)

Assuming initially all diodes are ON and can be replaced by short circuit,



Current, $I_1 = I_3 = \frac{10-(-10)}{8\,k\Omega} = \frac{20}{8\,k\Omega} = 2.5$ mA

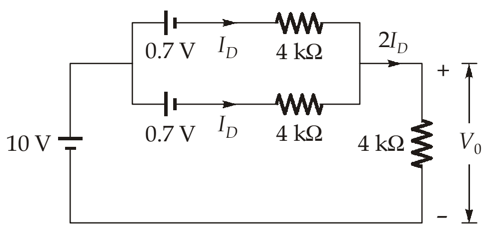
as no current is drawn from ground

$I_2 = 0$

$\therefore$ D_2 is in off state.

11. (b)

As current flows in both diodes from anode to cathode



Voltage across each parallel branch

$$V_p = 0.7 + (4\text{ k})(I_D)$$

By KVL in main loop,

$$-10 + 0.7 + (4\text{ k})(I_D) + 4\text{ k}(2I_D) = 0$$

$$-10 + 0.7 + 12\text{ k } I_D = 0$$

$$12\text{ k}(I_D) = 9.3$$

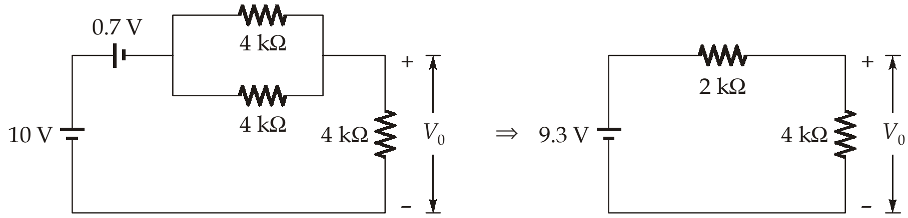
or $$I_D = 0.775\text{ mA}$$

So, output voltage, $$V_0 = (2I_D) \times 4\text{ k}\Omega$$

$$= 2 \times 0.775 \times 10^{-3} \times 4 \times 10^3$$

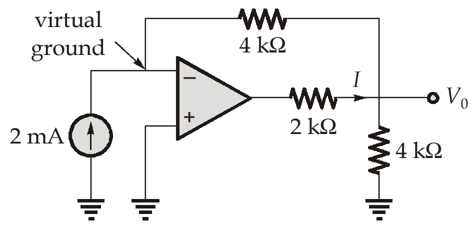
$$= 6.2\text{ V}$$

Alternate Solution:



$$V_0 = \frac{9.3 \times 4\text{k}}{(4+2)\text{k}} = 6.2\text{ V}$$

12. (b)



$$V_0 = 0 - (2 \times 10^{-3} \times 4 \times 10^3) = -8\text{ V}$$

Applying KCL at output node

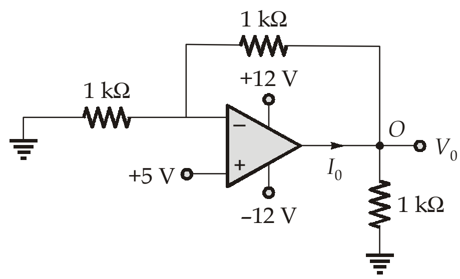
$$I + 2\text{ mA} = \frac{V_0}{4\text{k}\Omega}$$

$$I = -2\text{mA} - \frac{8}{4\text{k}\Omega} = -4\text{ mA}$$

13. (b)

Circuit can be redraw as

For non inverting configuration,



$$V_0 = \left(1 + \frac{R_f}{R_1}\right)V_s = (1 + 1)\,5$$

$$= 10\text{ V}$$

Applying KCL at node-O,

$$\frac{5-10}{1\text{k}\Omega} + I_0 + \frac{0-10}{1\text{k}\Omega} = 0$$

$$\frac{-5}{1\text{k}\Omega} + I_0 - \frac{10}{1\text{k}\Omega} = 0$$

$$I_0 = 15 \text{ mA}$$

14. (d)

Given,

$$R_1 = 14 \text{ k}\Omega,$$
$$R_2 = 6 \text{ k}\Omega,$$
$$R_S = 0.5 \text{ k}\Omega,$$
$$R_D = 1.2 \text{ k}\Omega$$

$$V_G = \frac{R_2}{R_1+R_2}\times 10 + \frac{R_1}{R_1+R_2}(-10)$$

$$= \frac{6\times 10}{20} - \frac{14}{20}\times 10 = -4\text{ V}$$

As transistor operating in saturation

$$I_D = \frac{V_S-(-10)}{R_S} = \frac{V_G - V_{GS} + 10}{R_S} = K_n(V_{GS}-V_{TN})^2$$

$$K_n = \frac{K_n'}{2}\frac{W}{L} = \frac{(60)(60\times 10^{-6})}{2} = 1.8 \text{ mA/V}^2$$

$$(1.8 \times 10^{-3})(V_{GS} - 2)^2 \times 0.5 \times 10^3 = -4 - V_{GS} + 10$$

$$0.\,9(V_{GS}^2 + 4 - 4\,V_{GS}) = 6 - V_{GS}$$

$$0.9V_{GS}^2 + 3.6 - 3.6V_{GS} = 6 - V_{GS}$$

$$0.9V_{GS}^2 - 2.6V_{GS} - 2.4 = 0$$

$\Rightarrow$ $V_{GS} = 3.62 \text{ V}, -0.73 \text{ V}$

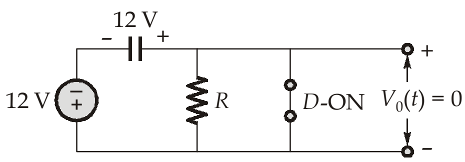
As V_{GS} is +ve so correct value $V_{GS} = 3.62$ V

$$I_D = \frac{V_G - V_{GS} + 10}{R_S}$$

$$= \frac{-4-3.62+10}{500} = 4.76 \text{ mA}$$

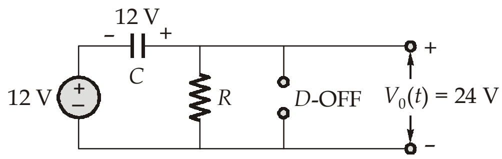
15. (c)

For given figure, when V_{in} is negative



Output is zero

When $V_i(t)$ is positive



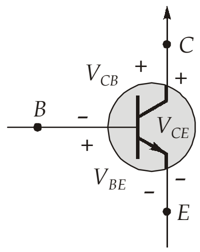
At t = 15 msec

The capacitor voltage and source voltage together will appear at the output :

$$12\text{ V} + 12\text{ V} = 24\text{ V}$$

16. **(a)**

As we know for a *n-p-n* BJT transistor



$$V_{CE} = V_{BE} + V_{CB}$$
$$= 0.7 + 0.2 = 0.9\text{ V}$$

Since, $V_{CE} > 0.2$ $[V_{CE(sat)} = 0.2\text{ V}]$

Therefore transistor is operating in active region.

17. **(a)**

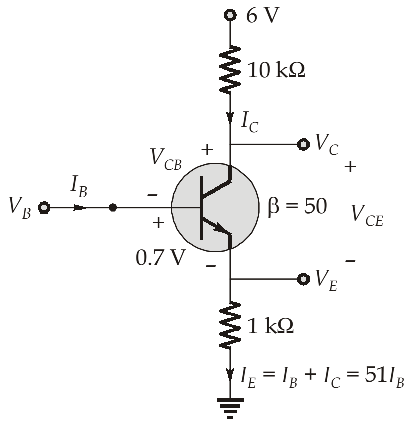
As we know,

$$I_S = I_Z + I_L$$
$$I_Z = I_S - I_L$$
$$I_{Z\,(min)} = I_{S\,(min)} - I_{L\,(max)}$$
$$2\text{ mA} = I_{S\,(min)} - 4\text{ mA}$$
$$I_{S\,(min)} = 6\text{ mA}$$
$$\frac{V_{i(min)} - V_Z}{R_S} = 6\text{ mA}$$
$$V_{i\,(min)} = 6 \times 5 + 50 = 80\text{ V}$$

and $$I_{Z\,(max)} = I_{S\,(max)} - I_{L\,(min)} \Rightarrow I_{s(rms)} = 8\text{ mA}$$

$$8 = \frac{V_{i(max)} - V_Z}{R_S} \Rightarrow V_{i\,(max)} = 8 \times 5 + 50 = 90\text{ V}$$

18. (c)



As we know, $V_{CE} = V_{BE} + V_{CB}$ $\quad [\because V_C = V_B \Rightarrow V_{CB} = 0\text{ V}]$

$$V_{CE} = 0.7\text{ V}$$

$$V_B = V_{BE} + V_E$$

$$I_C = \frac{6 - V_C}{10} = \frac{6 - 0.7 - V_E}{10} = 50I_B$$

$$5.3 - 500\,I_B = V_E$$

Also $V_E = 51\,I_B \times 1$

Therefore, $51\,I_B + 500\,I_B = 5.3$

$$I_B = 9.61 \times 10^{-3}\text{ mA}$$

$$I_C = \beta I_B = 9.61 \times 10^{-3} \times 50 = 0.48\text{ mA}$$

Hence, $V_C = 6 - I_C \times 10$

$$= 6 - 0.48 \times 10 = 1.19\text{ V}$$

Therefore, $V_B = V_C = 1.19\text{ V}$

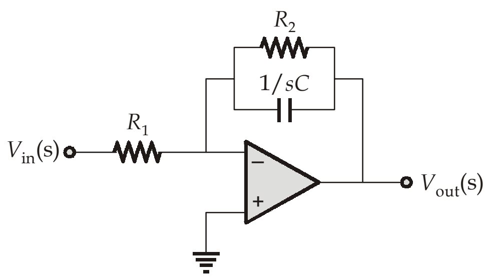
19. (b)

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial}{\partial V_{GS}}\left[K_n(V_{GS} - V_{\text{th}})^2\right]$$

$$= 2K_n(V_{GS} - V_{\text{th}})$$

20. (d)

Laplace equivalent circuit,



$$\frac{V_0(s)}{V_i(s)} = \frac{-R_2 \,||\, \left(\frac{1}{sC}\right)}{R_1}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{-R_2}{R_1} \times \frac{1}{1+sCR_2}$$

It is low pass filter with, $\omega_c = \dfrac{1}{R_2C}$

So, $f_c = \dfrac{1}{2\pi R_2 C}$

21. (d)

$$Q = 0.5\sqrt{\frac{C_2}{C_1}} = 0.5\sqrt{\frac{1.64 \text{ nF}}{820 \text{ pF}}} = 0.707$$

The pole frequency, $f_p = \dfrac{1}{2\pi R\sqrt{C_1C_2}} = \dfrac{1}{2\pi(30)\times 10^3\sqrt{820\times 1.64\times 10^{-21}}}$

$= 4.58$ kHz

Here $Q = 0.707$ tells us that this is a butterworth response, so cutoff frequency is the same as the pole frequency,

$$f_c = f_p = 4.58 \text{ kHz}$$

22. (d)

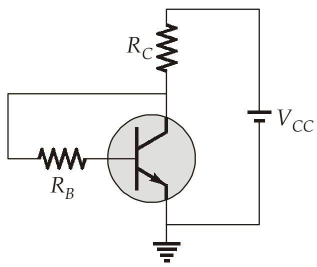
- In the circuit R_E provides feedback to the circuit, the feedback is directly connected to the output node. So voltage sampling.
- The feedback is not directly connected to input node, so series mixing.

So, feedback topology is voltage series feedback.

23. (b)

Applying KVL, we get

$$-V_{CC} + (I_B + I_C)R_C + I_BR_B + V_{BE} = 0$$



$$I_B = \frac{V_{CC} - I_CR_C - V_{BE}}{R_C + R_B}$$

Now, $\dfrac{dI_B}{dI_C} = \dfrac{-R_C}{R_C+R_B}$

$\therefore$ $S = \dfrac{1+\beta}{1-\beta\left(\dfrac{dI_B}{dI_C}\right)} = \dfrac{1+\beta}{1+\dfrac{\beta R_C}{(R_C+R_B)}}$

24. (a)

The diode current, $I_D = \dfrac{2.8-0.8}{2} = 1$ mA

The thermal voltage, $V_T = \dfrac{KT}{e} = \dfrac{1.38\times 10^{-23}\times 300}{1.6\times 10^{-19}} = 25.87$ mV

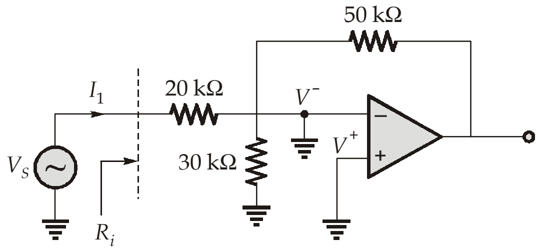
The dynamic resistance, $r_d = \dfrac{\eta V_T}{I_d} = \dfrac{2\times 25.87}{1}$

$r_d = 51.75\ \Omega \approx 52\ \Omega$

25. **(c)**

By concept of virtual short,

$$V^+ = V^- = 0 \text{ V}$$



$$R_i = \frac{V_s}{I_I} = 20 \text{ k}\Omega$$

26. **(b)**

For Silicon diode, $\frac{dV}{dT} \approx -2.5 \text{ mV/°C}$

Here, $dV = 640 - 700 = -60 \text{ mV}$

So, $dT = \frac{dV}{-2.5} = \frac{-60}{-2.5} = 24$

So, $T° = T_1 + dT = 30° + 24°$

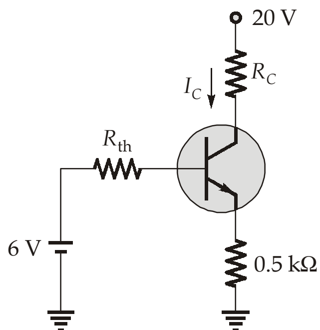
$T = 54° \text{ C}$

27. **(d)**

The Thevenin voltage, $V_{Th} = \frac{30}{30+70} \times 20 = 6 \text{ V}$

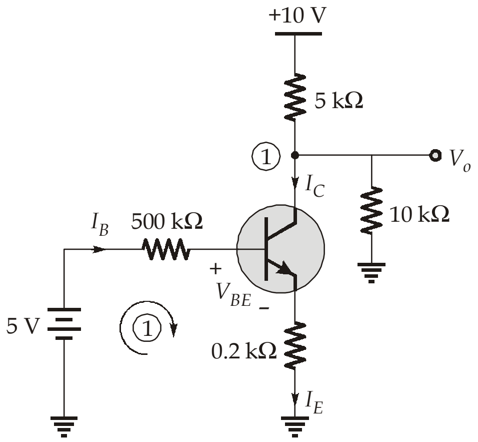
The Thevenin resistance $R_{Th} = 30 \| 70 = 21 \text{ k}\Omega$

The equivalent circuit



The operating state of BJT will be decided by value of R_C. According the value of R_C. BJT may be in active state or saturation state. So, I_C can not be found out.

28. (c)



The base current, $$I_B = \frac{V_{BB} - V_{BE}}{R_B + (1+\beta) R_E} = \frac{5 - 0.7}{500 + (1+100) \times 0.2}$$

$$I_B = 8.266 \ \mu A$$

So, collector current, $$I_C = \beta I_B = 0.8266 \text{ mA}$$

KCL at node (1),

$$I_C + \frac{V_o}{10} + \frac{V_o - 10}{5} = 0$$

$$0.8266 + \frac{V_o}{10} + \frac{V_o - 10}{5} = 0$$

$$V_0 = \frac{2 - 0.8266}{\left(\frac{1}{10} + \frac{1}{5}\right)} = 3.911 \text{ Volt}$$

and $$V_{CE} = V_o - V_E = 3.911 - 8.266 \times 10^{-3} \times 101 \times 0.20$$

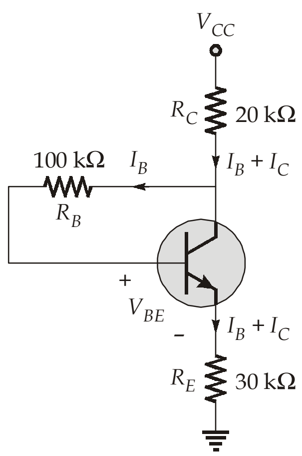
$$V_{CE} = 3.744 \text{ V} > 0.2$$

So, BJT is in active mode.

So, $$V_o = 3.91 \text{ Volt}$$

29. (a)

Applying KVL in the base-emitter loop



$+V_{BE} - V_{CC} + (I_C + I_B)R_C + I_B R_B + (I_C + I_B)(R_E) = 0$

Difference w.r.t. I_C

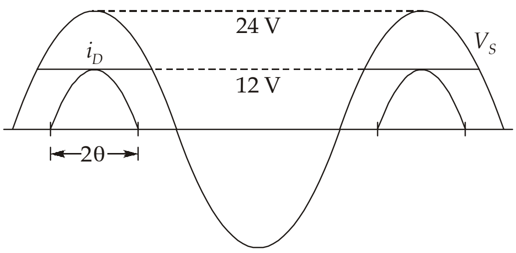
$$\left(1+\frac{\partial I_B}{\partial I_C}\right)(R_C+R_E)+\frac{\partial I_B}{\partial I_C}R_B = 0$$

$$\frac{\partial I_B}{\partial I_C} = -\frac{(R_C+R_E)}{R_C+R_B+R_E}$$

$$\frac{\partial I_B}{\partial I_C} = \frac{-(20+30)}{100+20+30} = -\frac{1}{3}$$

So, stability factor, $$S = \frac{1+\beta}{1-\beta\frac{\partial I_B}{\partial I_C}} = \frac{1+99}{1-99\left(-\frac{1}{3}\right)} = 2.94$$

30. **(b)**



The diode conducts when V_s exceeds 12 V, as shown above,

The conduction angle is 2 θ, where θ is given by

$$24\cos\theta = 12$$

$$\theta = 60°$$

and the conduction angle is 120°

That is $\frac{1}{3}$ of a cycle.

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